AYK Chinook Stock Separation

Report #12

ORIGINS OF CHINOOK SALMON (<u>Oncorhynchus</u> <u>tschawytscha</u> Walbaum) IN THE YUKON RIVER FISHERIES, 1986

by

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ABSTRACT

Analysis of scale patterns and age composition of chinook salmon (*Oncorhynchus tschawytscha* Walbaum) from Yukon River escapements in Alaska and tagging fishwheel samples in Canada were used to construct run and river of origin classification models for ages 1.4 and 1.3 fish. Samples from the Nulato and Jim Rivers, Alaska, were collected in 1986 and for the first time included in various models. Yukon River commercial and subsistence catches will be apportioned to river or run of origin with the model which yields the best classification accuracy and allocation precision.

KEY WORDS: chinook salmon, *Oncorhynchus tschawytscha*, stock separation, linear discriminant analysis.

INTRODUCTION

Yukon River chinook salmon (Oncorhynchus tschawytscha Walbaum) are harvested in a wide range of fisheries in both marine and fresh waters. During their ocean residence, they are harvested in salmon gillnet fisheries in the North Pacific Ocean and Bering Sea and in trawl fisheries in the Bering Sea. Upon returning to the Yukon River as adults, they are harvested in a variety of commercial and subsistence fisheries in both Alaska and Canada (Figures 1 and 2).

A major controversy currently facing managers of Yukon River chinook salmon is allocation of the harvest among the various user groups. Two such allocation issues which have recently received considerable public attention are: (1) high seas interceptions of North American chinook salmon (including fish destined for the Yukon River) in the gillnet and trawl fisheries in the North Pacific Ocean and Bering Sea; and (2) negotiations between the United States and Canada over inriver harvest of chinook salmon destined for the Canadian portion of the Yukon River drainage.

Identification of stock groupings and estimation of their contribution rates is becoming an increasingly important facet of Yukon River chinook salmon management. Contribution estimates of Western Alaskan/Canadian Yukon Territory chinook salmon, recently estimated for the Japanese high seas gillnet fisheries (Rogers et al. 1984, Meyers et al. 1984, Meyers and Rogers 1985), have become major elements in the regulation of these ocean fisheries. Concurrent with offshore studies, stock composition of inriver fisheries has been studied to provide useful information for resource administrators making inriver allocation decisions and managers seeking to improve management precision through a better understanding of stock-specific production units and their spatial/temporal migratory patterns. Stock composition estimates through time for Yukon River chinook salmon became available in 1980 and 1981 when the feasibility of apportioning catches using scale patterns analysis for District 1 catches was initially investigated (McBride and Marshall 1983). Since then, the entire drainage harvest has been apportioned annually to geographic region of origin (Wilcock and McBride 1983, Wilcock 1984, Wilcock 1985, Wilcock 1986).

The Yukon River combined commercial and subsistence chinook salmon fishery is one of the largest in Alaska, averaging 17% of statewide chinook salmon harvest annually (1980-1984). In the first 20 years after statehood (1960-1979), combined Alaskan and Canadian Yukon River chinook salmon harvest averaged 122,971 fish annually. However, catches during the recent five years (1982-1986) have increased substantially to an average of 183,481 fish annually. While chinook salmon are harvested virtually throughout the entire length of the Yukon River, the majority of

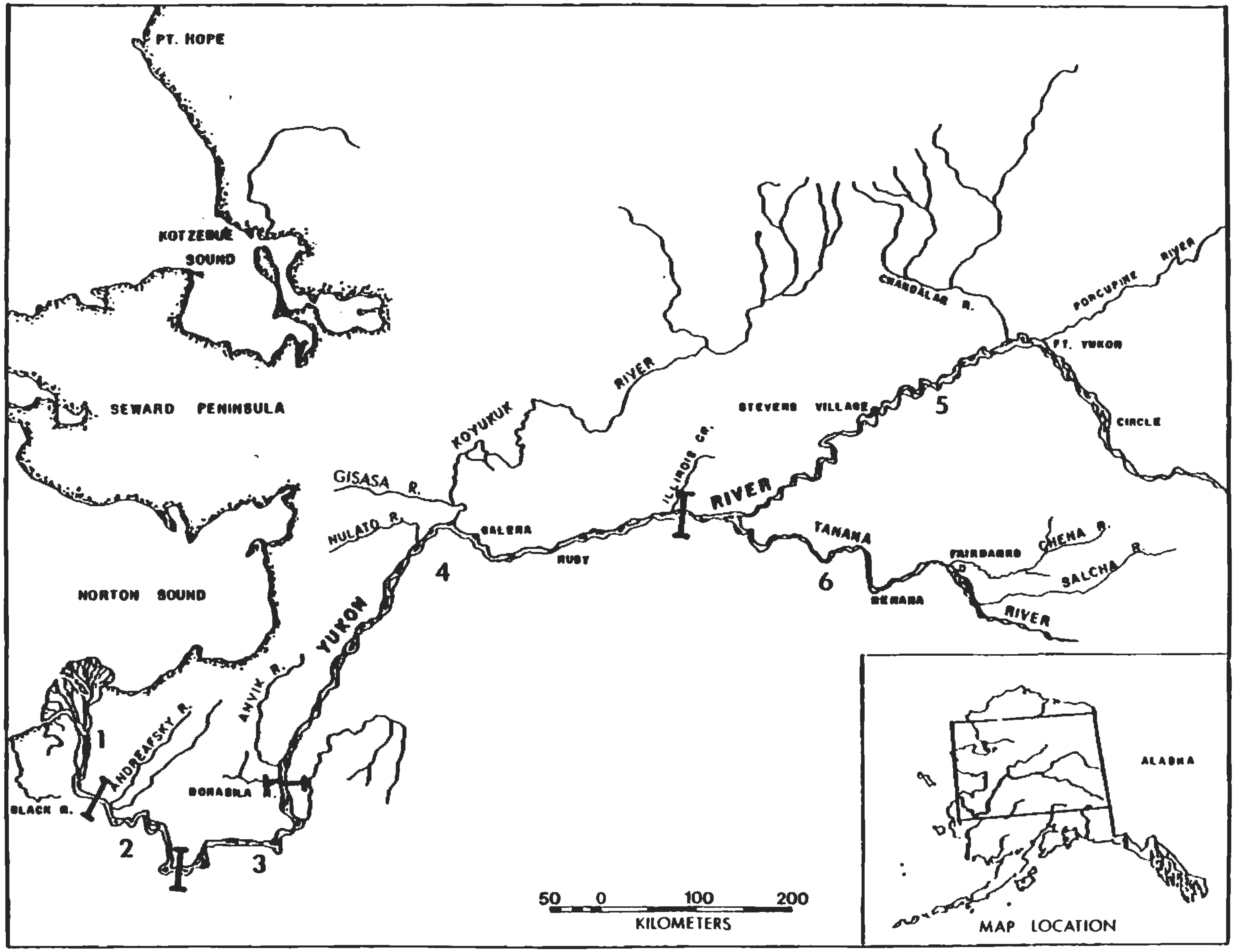

Figure 1. Alaskan portion of the Yukon River showing the six regulatory districts.

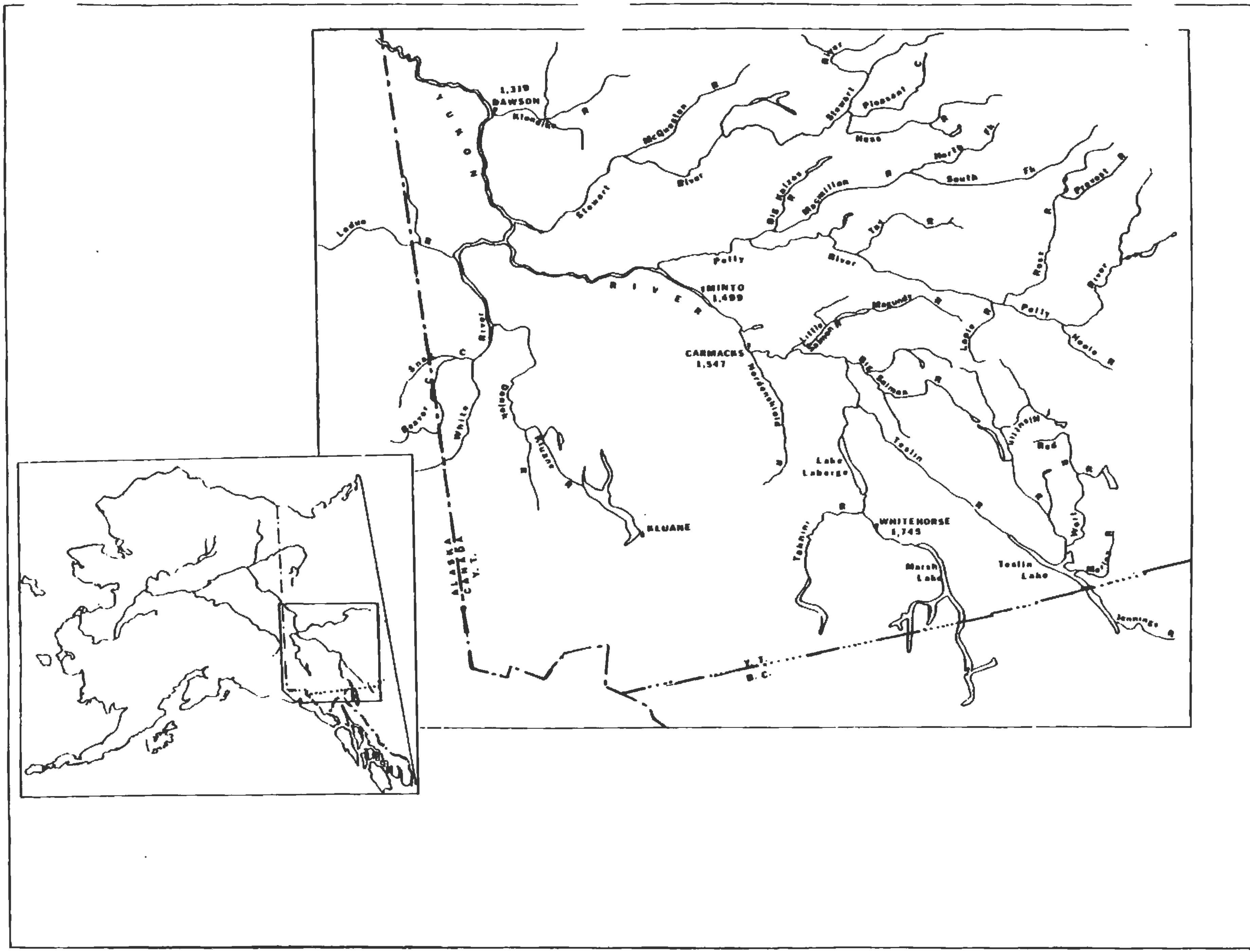

Figure 2. Canadian portion of the Yukon River.

the catch is taken in commercial gillnet fisheries in Districts 1 and 2 (1982-1986 average 65% of total drainage harvest). Subsistence harvests, including Canadian catches, account for another 25% (1982-1986 average) of the total harvest. Most of the subsistence harvest is taken with fishwheels and gill nets in Districts 4, 5, and 6. In 1986, commercial and subsistence fishermen in Alaska and Canada harvested a total of 165,316 chinook salmon, of which 94,884 fish (57%) were taken by District 1 and 2 commercial fishermen.

Chinook salmon harvested in the Yukon River fisheries consist of a mixture of stocks destined for spawning areas throughout the Yukon River drainage. Although more than 100 spawning streams have been documented (Barton 1984), aerial surveys of chinook salmon escapements indicate that the largest concentrations of spawners occur in three distinct geographic regions: (1) tributary streams that drain the Andreafsky Hills and Kaltag Mountains between river miles 100 and 500; (2) Tanana River tributaries between river miles 800 and 1,100; and (3) tributary streams that drain the Pelly and Big Salmon Mountains between river miles 1,300 and 1,800. Chinook salmon stocks within these geographic regions are termed runs (McBride and Marshall 1983) and have previously been defined as lower, middle, and upper Yukon runs, respectively.

The U.S./Canada Joint Technical Committee (JTC) on Yukon River salmon recommended in April 1987 that chinook salmon be allocated to river of origin, where possible, and that these stock allocations could then be summed to yield run of origin allocation estimates (Yukon River JTC, 1987). It was suggested that this approach may yield greater precision and similiar accuracy as the method used previously in this study. In past years, scales from different tributaries were pooled, weighted by aerial survey indices of abundance, to form run of origin standards. Both because of this recommendation by the JTC, and because escapement samples were collected from the Nulato and Jim Rivers in Alaska in 1986 for the first time, this new allocation method will be tested. Several different allocation models will be constructed for the 1986 data base, and that method which yields the best classification accuracy and allocation precision will be selected for the final estimates of catch by river or run of origin.

This report builds upon the catch, escapement, and age composition database compiled by Buklis (In Prep.) for the 1986 return of salmon to the Yukon River. The objective is to apportion the 1986 Yukon River chinook salmon commercial and subsistence harvest to river of origin or run of origin, whichever provides the greatest precision. Commercial catches from Districts 1, 2, and 3 will be allocated to river or run of origin by analysis of scale patterns of age 1.4 and 1.3 fish[1], and catch and escapement age composition data. Estimates of the contribution by river or run of origin in commercial catches will then be applied to subsistence catches from these districts. Commercial and subsistence catches from Districts 5 and 6, and the Yukon Territory will be allocated based on geography. Pooled commercial and subsistence catches from District 4 will be allocated based on geography, scale pattern analysis of age 1.4 and 1.3 fish, and catch and escapement age composition data.

METHODS

Age Composition

Scale samples provided age information for fish in the catch and escapement. Samples were collected on the left side of the fish approximately two rows above the lateral line and on the diagonal row downward from the posterior insertion of the dorsal fin (Clutter and Whitesel 1956). Scales were mounted on gummed cards and impressions made in cellulose acetate.

Catch:

Scales were collected from commercial catches in Districts 1, 2, 4, 5, 6, and the Yukon Territory, Canada, and from subsistence catches in Districts 4,5, and 6. District 3 was not sampled because few fish are traditionally harvested in that portion of the Yukon River and access is difficult. Although subsistence catches were not sampled in Districts 1 and 2, subsistence fishing occurred concurrently with commercial effort and the age compositions for subsistence catches were assumed to be similiar to the commercial catch. Samples were also collected from a test gillnet fishery in District 1 and from a test fishwheel used to capture fish in a tagging project in the Yukon Territory. Sampling of Alaskan fisheries was conducted by the Alaska Department of Fish and Game (ADF&G), Division of Commercial Fisheries, while Canadian fishery and test fishwheel samples were collected by the Canadian Department of Fisheries and Oceans (DFO).

Escapement:

Scale samples were collected during peak spawner die off from theAndreafsky, Anvik, Nulato, Jim, Chena, and Salcha Rivers in Alaska, and from the Big Salmon, Little Salmon, Nisutlin, Teslin, Tatchun, and mainstem Yukon Rivers in Canada. Virtually all

1 European formula: the first numeral refers to the number of freshwater annuli present on scales of the fish and represents the number of years of freshwater residence minus one (freshwater residence prior to scale formation). The second number refers to the marine age of the fish. Total age is the arithmetic sum of these two numbers plus one.

samples were collected from carcasses. The age composition of lower, middle, and upper Yukon areas will be estimated by weighting the age compostion calculated for the individual spawning tributaries in each area by the escapement to each tributary as indexed by aerial surveys.

Catch Apportionment

Linear discriminant function analysis (Fisher 1936) of scale patterns data and observed differences in age composition between escapements will be used to allocate 1986 Yukon River chinook salmon catches to river or run of origin.

Scale Patterns Analysis:

Escapement samples in Alaska and Yukon Territory fishwheel tagging site samples provided scales of known origin that were used to build linear discriminant functions (LDF). The Canadian standard was based on tagging fishwheel samples in 1986 because the Canadian commercial fishery was terminated early due to marketing problems. It was felt that some spawning stocks might not be adequately represented in the commercial fishery sample for 1986. Canadian escapement samples could not be pooled to form a reasonable standard due to the lack of samples from significant spawning populations in the Stewart and Pelly River drainages.

Catch and test fishing samples provide scales of mixed stock composition which will be classified using the discriminant functions. Proportions of river or run of origin fish ages 1.4 and 1.3 will be estimated in District 1 and 2 catches by fishing period. It will be assumed that District 3 catch allocations are similiar to those in District 2. District 4, 5 and 6 catches will be allocated for the entire season, not by fishing period.

Model Construction. Measurements of scale features were made as described by McBride and Marshall (1983). Scale images were projected at 100X magnification using equipment similar to that described by Ryan and Christie (1976) and measurements were made and recorded by a microcomputer-controlled digitizing system. Measurements were taken along an axis approximately perpendicular to the sculptured field and the distance between each circulus in each of three scale growth zones (Figure 3) was recorded. The three zones were: (1) scale focus to the outside edge of the freshwater annulus (first freshwater annular zone), (2) outside edge of the freshwater annulus to the last circulus of freshwater growth (freshwater plus growth zone), and (3) the last circulus of the freshwater plus growth zone to the outer edge of the first ocean annulus (first marine annular zone). In addition, the total width of successive scale patterns zones was also measured for: (1) the last circulus of the first ocean annulus to the last circulus of the second ocean annulus (ages 1.4 and 1.3), and (2) the last circulus of the second ocean annulus to the last circulus of the third ocean annulus (age 1.4 only). Seventy-nine scale characters (Apppendix Table 1) were calculated from the

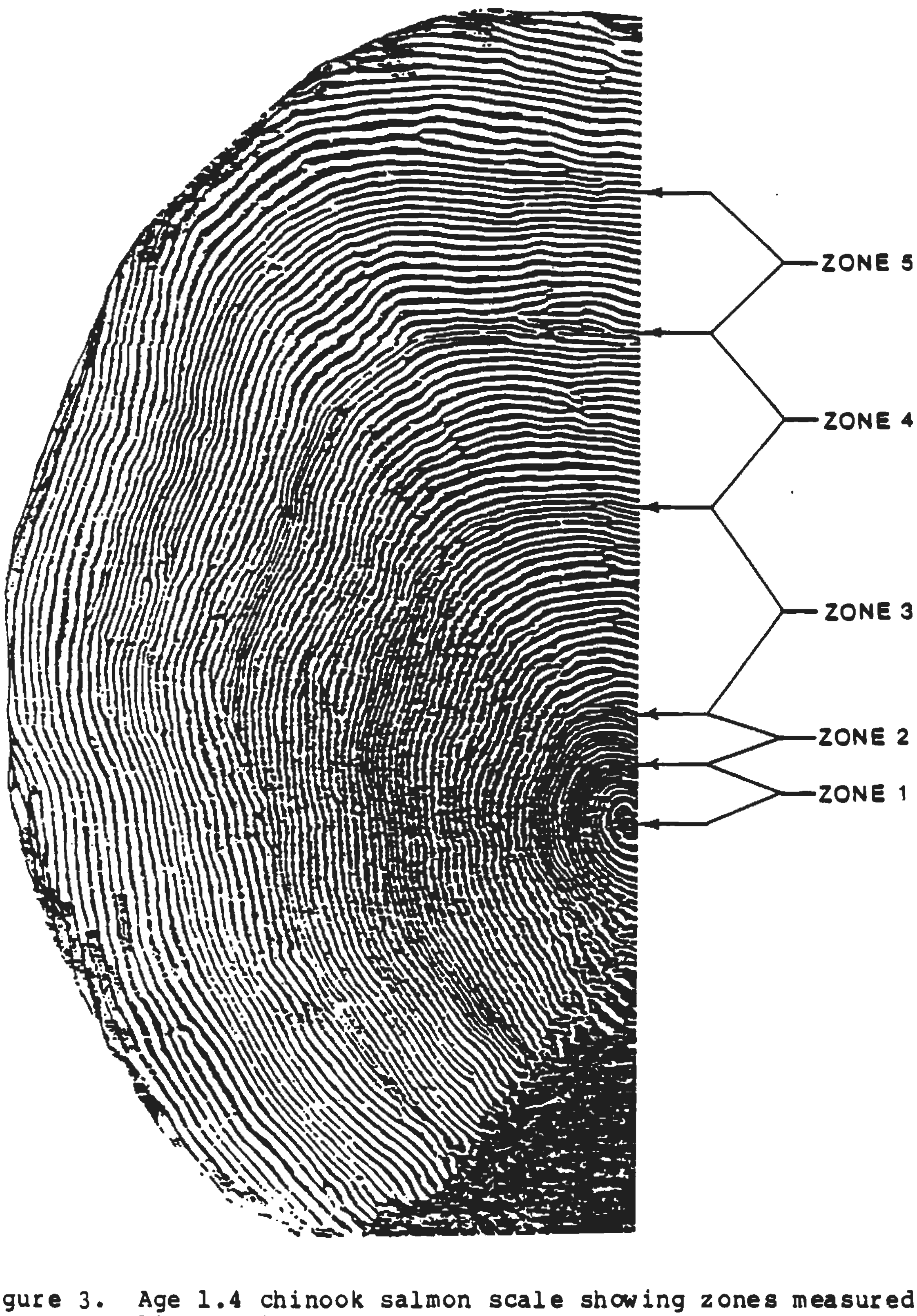

Figure 3. Age 1.4 chinook salmon scale showing zones measured for linear discriminant analysis.

basic incremental distances and circuli counts. All available scale samples (standards) representing six rivers in Alaska (Andreafsky, Anvik, Nulato, Jim, Chena, Salcha) and 200 systematically-pooled samples from three Canadian fishwheel tagging sites comprised the primary river of origin model. Run of origin (pooled river) standards were weighted by aerial abundance estimates. River and run of origin models were constructed for the 1.4 and 1.3 age classes.

Classification Linear discriminant functions (LDF) were calculated for each age class. Selection of scale characters for each analysis was by a forward stepping procedure using partial F statistics as the criteria for entry/deletion of variables (Enslein et al. 1977). A nearly unbiased estimate of classification accuracy for each LDF was determined using a leaving-one-out procedure (Lachenbruch 1967).

Contribution rates for ages 1.4 and 1.3 fish in the District 1 and 2 catches will be estimated for each fishing period. Contribution rates for the combined commercial and subsistence harvests in District 4 will be estimated from samples collected from both fisheries (including both gillnet and fishwheel gear types) during most of the season. Point estimates will be adjusted for misclassification errors using the procedure of Cook and Lord (1978). The variance and 90% confidence intervals for these estimates will be computed using the procedures of Pella and Robertson (1979).

If classifed catch samples indicate an adjusted proportional estimate equal to or less than zero, the river or run indicating the most negative contribution will be deleted from the model. Data will then be resubmitted to the variable selection routines and a new subset of variables chosen for the LDF. Catch will then be reclassified. This process will be continued until all adjusted proportional estimates in the catch are positive.

Results of the age-specific scale patterns analysis will be summed to estimate total contribution by river or run of origin for age 1.4 and 1.3 chinook salmon from the District 1, 2, and 3 commercial and District 4 combined commercial and subsistence catches. For each district, the variance (V) around N_{ijt} (the catch of age class i and run j during period t) will be computed for each period t as follows:

$$V[N_{ijt}] = N_t^2\{S_{ijt}^2 \cdot V[P_{it}] + P_{it}^2 \cdot V[S_{ijt}] - V[P_{it}] \cdot V[S_{ijt}]\}$$

where:

$$V[P_{it}] = \frac{P_{it}(1-P_{it})}{n_t-1}$$

P is the proportion of age class i; S is the proportion of run j of age class i harvested during period t; and the variance, $V[S_{ijt}]$, is as derived by Pella and Robertson (1979). Variance around the district catch of ages 1.4 and 1.3 by run, N_j, will be computed by summing variances across age classes and periods:

$$V[N_j] = \sum_{t}^{T} \sum_{i}^{2} V[N_{ijt}] + 2 \sum_{t}^{T} \sum_{i>k}^{2} \sum^{2} N_t^2 \cdot Cov[P_{it}P_{kt}] \cdot S_{ijt} \cdot S_{kjt}$$

where:

$$Cov[P_{it}P_{kt}] = - \frac{P_{it}P_{kt}}{n_t - 2}$$

T is the total number of fishing periods sampled in each district and n_t is the sample size for the estimate of age composition in period t. Variance around the estimate of total harvest of ages 1.4 and 1.3 fish by river or run of origin from Districts 1, 2, 3, and 4 estimated from scale patterns analysis will be calculated as the sum of the seasonal variances for combined ages across all districts. Total harvest estimates and associated variances by country of origin will be calculated by assuming the sum of the Alaskan rivers or the lower and middle Yukon runs to be equal to the Alaskan contribution and the upper Yukon equal to the Canadian contribution. Variance around the estimate of Alaskan contribution, $N_{i(L+M)t}$, will be computed by summing variances across runs:

S_{iLt} = estimated proportion of lower Yukon run present for age i at period t

S_{iMt} = estimated proportion of middle Yukon run present for age i at period t

$$V[N_{i(L+M)t}] = N_t^2\{(S_{iLt}+S_{iMt})^2 \cdot V[P_{it}] + P_{it}^2 \cdot V[S_{iLt}+S_{iMt}] - V[P_{it}] \cdot V[S_{iLt}+S_{iMt}]\}$$

where:

$$V[S_{iLt}+S_{iMt}] = V[S_{iLt}] + V[S_{iMt}] - 2Cov[S_{iLt}S_{iMt}]$$

Differential **Age** Composition Analysis:

Allocation of the remaining age classes in the District 1, 2, and 3 commercial catches and District 4 combined commercial and subsistence catches will be based on differences in escapement age composition in each river or run of origin. Escapement age composition data will be directly compared by computing ratios for each river or run whereby the proportion in the escapement of the age class in question will be divided by the proportion in the escapement of an age class of known catch composition estimated by scale patterns analysis (either age 1.4 or 1.3):

E_{ci} = Proportion of fish of age class i in river or run c escapement samples where i is an age class of unknown river or run composition in the catch

E_{ca} = Proportion of fish of age class a in river or run c where a is an age class of known river or run composition in the catch (either age 1.4 or 1.3)

$R_{ci} = E_{ci}/E_{ca}$

Because the relative contribution of age 1.2 fish decreased in escapement samples moving progressively upriver, this age class was compared to age 1.3 fish. All other age classes (2.3, 1.5, 2.4, and 2.5) were compared to age 1.4 fish since the relative contributions of each of these age classes increased in escapement samples moving progressively upriver. These ratios of proportional abundance will then be multiplied by the allocated catch of either age 1.3 or 1.4 fish. These computations will be summed over all runs to calculate age-specific contribution rates. Multiplication by total catch by age class yields age-specific river or run contribution estimates:

N_i = Total catch of age group i

N_{ca} = Catch of age group a (where a is either age 1.4 or 1.3) in river or run c

F_{ci} = Proportion of fish of river or run c in N_i

$$F_{ci} = \frac{R_{ci} \cdot N_{ca}}{\sum_{j=1}^{3} R_{ji} \cdot N_{ja}}$$ (where j is river or run number)

The total harvest of river or run c for age group i is then:

$N_{ci} = F_{ci} \cdot N_i$

Catch Allocation Based on Geography:

Catches in Districts 5, 6, and the Yukon Territory will be allocated to run based on geography. The entire District 5 harvest will be allocated to the upper Yukon run as most of the District 5 catch occured above the confluence of the Tanana River, and there are few documented spawning concentrations between the Tanana River confluence and the Yukon Territory fishery centered in Dawson. The entire District 6 harvest will be allocated to the middle Yukon run, since neither lower nor upper runs are present in the Tanana River. The Yukon Territory harvest will be allocated to the upper run since neither lower nor middle runs are present in the Yukon Territory.

RESULTS AND DISCUSSION

Age Composition

Ages 1.3 and 1.5 fish comprised a greater proportion of fish sampled in all Alaskan rivers and in most Canadian rivers than found in previous years for each of these rivers (Table 1). The weaker age 1.4 contribution to escapements as compared with samples from earlier years indicates relatively poor productivity and/or survival from the 1980 brood year. Increasing proportions of older-age fish in escapements progressing upriver were similiar to trends observed in prior years. Age 1.5 fish generally increased in relative abundance from 5.8% and 10.6% in the Andreafsky and Anvik Rivers, respectively, to an average of 20.0% for Canadian rivers combined. Conversely, the proportion of age 1.3 fish declined from 69.8% and 50.0% in the Andreafsky and Anvik Rivers, respectively, to an average of 13.9% for Canadian rivers combined.

The greatest proportion of 2- freshwater age fish were found in the Nisutlin River, comprising 33.9% of the sample from this river. In past years, 2-freshwater age fish were primarily found in upper river samples. However, samples from the Jim River in 1986 showed a relatively high proportion of ages 2.2, 2.3 and 2.4 fish (9.0% combined) compared to other samples collected in interior Alaska.

Classification Accuracies of Run and River of Origin Models

Age 1.4:

A 3-way run of origin model using the same pooled-river standards as in previous years (lower: Andreafsky and Anvik Rivers; middle: Chena and Salcha Rivers; upper: Canada) gave a mean classification accuracy of 69.6% (Table 2A), 2.1 times greater than random chance. Model classification accuracy of age 1.4 fish in 1986 is slightly less than in 1985 (71.1%). The only difference in the model presented in Table 2A from models used in previous years is that the upper river standard is composed of Canadian test fishwheel samples and not Canadian fishery gillnet samples. Similiar to past years, the lower river standard showed the greatest classification accuracy (86.4%). Middle and upper river standards showed the least classification accuracy (62.6% and 59.8%, respectively), misclassifying primarily to each other. Misclassification between middle and upper river standards has been observed every year since initiation of the Yukon River chinook salmon stock identification study in 1980.

A second 3-way model was constructed which included samples from the Nulato River in the lower river standard (Table 2B). The Nulato River was included into the lower river standard because analysis of variance tests indicated little difference in mean value of important scale variables among the Nulato, Andreafsky

Table 1. Age composition summary of Yukon River chinook salmon escapements, 1986.

River	Aerial Survey Est.	Sample Size	1983	1982	1981		1980		1979		1978
			1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	2.5
Andreafsky	5,112	275[1]	0.0	2.2	69.8	0.0	21.5	0.4	5.8	0.4	0.0
Anvik	1,118	142[2]	0.0	0.7	50.0	0.0	38.0	0.0	10.6	0.7	0.0
Nulato	2,974	189	0.0	1.6	50.3	0.5	31.2	0.0	15.3	1.1	0.0
Jim	238	166	0.0	3.0	48.2	1.2	25.3	4.8	12.0	3.0	2.4
Chena	2,288[3]	729	0.1	9.3	51.2	0.0	28.5	1.4	9.2	0.1	0.1
Salcha	3,368	586	0.2	11.8	43.7	0.0	28.5	1.0	14.8	0.0	0.0
Big Salmon	745[4]	233	0.0	1.7	21.9	0.9	41.2	5.6	19.7	6.0	3.0
Little Salmon	54[5]	58	0.0	0.0	20.7	0.0	39.7	10.3	20.7	5.2	3.4
Nisutlin	703	177	0.0	0.0	2.8	0.0	40.7	2.8	11.9	31.1	10.7
Tatchun	155[6]	2	0.0	50.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0
Teslin	-	34	0.0	5.9	8.8	0.0	41.2	0.0	38.2	2.9	2.9
Mainstem Yukon	-	30	0.0	0.0	10.0	0.0	30.0	0.0	46.7	0.0	13.3

Column group heading: Brood Year and Age Group

1 Includes 17 East Fork beach samples, 81 East Fork carcass samples, and 177 West Fork carcass samples.
2 Includes 3 beach seine samples.
3 Includes carcasses removed by tag recovery crew before date of aerial survey.
4 ADF&G aerial survey above Souch Cr.
5 Incomplete or poor survey conditions resulting in a minimal count.
6 Foot survey, DFO, Canada.

Table 2. Classification accuracies of linear discriminant run of origin models for age 1.4 Yukon River chinook salmon, 1986.

A. 3-way as done in previous years
(Lower:Andreafsky, Anvik; Middle: Chena, Salcha; Upper: Canada Tagging)

Region of Origin	Sample Size	Classified Region of Origin Lower	Middle	Upper
Lower	44	<u>0.864</u>	0.023	0.114
Middle	187	0.102	<u>0.626</u>	0.273
Upper	199	0.181	0.221	<u>0.598</u>

Mean Classification Accuracy: <u>0.696</u>
Variables in the Analysis: 67,62,102,26,85,61

B. 3-way including Nulato River sample
(Lower: Andreafsky, Anvik, Nulato; Middle: Chena, Salcha; Upper: Canada Tagging)

Region of Origin	Sample Size	Classified Region of Origin Lower	Middle	Upper
Lower	65	<u>0.785</u>	0.077	0.138
Middle	184	0.082	<u>0.658</u>	0.261
Upper	200	0.192	0.250	<u>0.560</u>

Mean Classification Accuracy: <u>0.667</u>
Variables in the Analysis: 67,100,26,61,70,89,8,2

C. 4-way including Nulato and Jim River samples
(Lower: Andreafsky, Anvik, Nulato; Koyukuk: Jim; Middle: Chena, Salcha; Upper: Canada Tagging)

Region of Origin	Sample Size	Classified Region of Origin Lower	Koyukuk	Middle	Upper
Lower	61	<u>0.574</u>	0.262	0.049	0.115
Koyukuk	23	0.261	<u>0.391</u>	0.217	0.130
Middle	136	0.037	0.184	<u>0.574</u>	0.206
Upper	186	0.194	0.124	0.210	<u>0.473</u>

Mean Classification Accuracy: <u>0.503</u>
Variables in the Analysis: 67, 26, 61, 100, 85

and Anvik Rivers. These three rivers are located in the same lower Yukon geographic area. Mean classification accuracy of this model was 66.7%, 2.0 times greater than random chance. Again, the lower river standard had the greatest classification accuracy (78.5%) and the upper river standard had the least (56.0%). Misclassification trends were similiar to those of the model in Table 2A.

A 4-way model was constructed with the Nulato River included in the lower river standard and the Koyukuk River (Jim River escapement) as a fourth standard (Table 2C). Middle and upper river standards were the same as in the preceeding 3-way models. The Koyukuk River was chosen as a fourth standard because in analysis of variance tests using run of origin data for age 1.4 fish, scale variables in samples from the Koyukuk River neither resembled nor were distinctive from other Alaskan escapement samples. Geographically, the confluence of the Koyukuk River with the Yukon River is located between the lower and middle river regions. However, chinook salmon spawning populations in the upper Koyukuk River drainage are about as far from the mouth of the Yukon River as is the Candaian border, and were the northern most samples collected in this study. Mean classification accuracy for this 4-way model was 50.3%, 2.0 times greater than random chance. The lower and middle river standards showed the greatest classification accuracy (57.4% each), while the Koyukuk River showed the least (39.1%). Koyukuk River samples misclassify primarily to lower and middle river fish in this age 1.4 model.

Mean classification accuracy of a 7-way river of origin model (six Alaskan escapements and pooled Canadian tagging fishwheel samples) was 38.4%, or 2.7 times greater than random chance (Table 3). The Chena River showed the greatest classification accuracy (54.6%) while the Anvik River showed the least (19.2%). Andreafsky, Anvik and Nulato Rivers classify primarily among themselves as a group (75.7%, 57.6% and 82.5%, respectively) supporting pooling of these rivers into a lower river standard. Samples from the Jim River misclassified in equal proportions (30.4%) to escapements downriver and upriver from the confluence of the Koyukuk and Yukon Rivers. These results indicate that sampling of the Koyukuk River drainage should be expanded, and scale patterns more fully examined. Chena and Salcha Rivers classify primarily to each other as a group (73.2% and 61.0%, respectively) supporting pooling of these rivers into a middle river standard. Misclassification of age 1.4 Canadian tagging fishwheel samples to Alaskan rivers was 69.2%. However, of 301 Alaskan escapement samples collected and classified in this age 1.4 model, 10.0% misclassified to Canada.

Age 1.3:

A 3-way run of origin model using the same pooled-river standards as in previous years gave a mean classification accuracy of 83.4% (Table 4A), which is 2.5 times greater than random chance. Model classification accuracy of age 1.3 fish in 1986 is the highest on

Table 3. Classification accuracy of a linear discriminant river of origin model for age 1.4 Yukon River chinook salmon, 1986.

7-way including each Alaskan escapement sampled and Canadian tagging sample (Andreafsky, Anvik, Nulato, Jim, Chena, Salcha, Canada Tagging)

River of Origin	Sample Size	Classified River of Origin						
		Andreafsky	Anvik	Nulato	Jim	Chena	Salcha	Can. Tag
Andreafsky	33	0.424	0.030	0.303	0.152	0.000	0.030	0.061
Anvik	26	0.192	0.192	0.192	0.154	0.077	0.038	0.154
Nulato	40	0.225	0.150	0.450	0.075	0.075	0.000	0.025
Jim	23	0.174	0.087	0.043	0.391	0.000	0.174	0.130
Chena	97	0.010	0.062	0.052	0.062	0.546	0.186	0.082
Salcha	82	0.024	0.012	0.024	0.183	0.232	0.378	0.146
Can. Tag	185	0.092	0.168	0.065	0.065	0.200	0.103	0.308

Mean Classification Accuracy: 0.384

Variables in the Analysis: 67,8,102,61,30,85,26,70,106

Table 4. Classification accuracies of linear discriminant run of origin models for age 1.3 Yukon River chinook salmon, 1986.

A. 3-way as done in previous years
(Lower: Andreafsky, Anvik; Middle: Chena, Salcha; Upper: Canada Tagging)

Region of Origin	Sample Size	Classified Region of Origin Lower	Middle	Upper
Lower	143	0.965	0.000	0.035
Middle	132	0.023	0.758	0.220
Upper	199	0.030	0.191	0.779

Mean Classification Accuracy: 0.834
Variables in the Analysis: 67,1,83,61,26,103,72,21,71,18

B. 3-way including Nulato River sample
(Lower: Andreafsky, Anvik, Nulato; Middle: Chena, Salcha; Upper: Canada Tagging)

Region of Origin	Sample Size	Classified Region of Origin Lower	Middle	Upper
Lower	211	0.953	0.014	0.033
Middle	132	0.053	0.705	0.242
Upper	199	0.025	0.211	0.764

Mean Classification Accuracy: 0.807
Variables in the Analysis: 67,62,27,61,83,14,106,8,1,16

C. 4-way including Nulato and Jim River samples
(Lower: Andreafsky, Anvik, Nulato; Koyukuk: Jim; Middle: Chena, Salcha; Upper: Canada Tagging)

Region of Origin	Sample Size	Classified Region of Origin Lower	Koyukuk	Middle	Upper
Lower	211	0.943	0.033	0.009	0.014
Koyukuk	55	0.109	0.509	0.145	0.236
Middle	132	0.061	0.076	0.674	0.189
Upper	199	0.015	0.286	0.216	0.482

Mean Classification Accuracy: 0.652
Variables in the Analysis: 67,62,27 61 83,72

record. Similiar to past years, the lower river standard showed the greatest classification accuracy (96.5%), which increases the mean accuracy of the model. Middle and upper river standards showed the least accuracy (75.8% and 77.9%, respectively), misclassifying primarily to each other.

A second 3-way model was constructed which included samples from the Nulato River in the lower river standard (Table 4B). The Nulato River was included in the lower river standard because, similiar to age 1.4 fish, analysis of variance tests indicated little difference in mean value for important scale variables among the Nulato, Andreafsky and Anvik Rivers. Mean classification accuracy was 80.7%, 2.4 times greater than random chance. Again, the lower river standard had the greatest classification accuracy (95.3%) and the middle river standard had the least (70.5%). Misclassification trends were similiar to those in the model in Table 4A.

A 4-way model was constructed which included the Nulato River in the lower river standard and the Koyukuk River (Jim River escapement) as a fourth standard (Table 4C). Middle and upper river standards were the same as in the preceeding 3-way models.In analysis of variance tests using run of origin scale variable data from age 1.3 fish, Koyukuk scale variables were significantly different from lower river standards, although not as distinctive from middle river standards. Mean classification accuracy for this 4-way model was 65.2%, 2.6 times greater than random chance. Similiar to age 1.4 fish, the lower and middle river standards showed the greatest classification accuracy (94.3% and 67.4%, respectively). However, in contrast to the age 1.4 model, Canada showed the poorest classification accuracy (48.2%), and age 1.3 Koyukuk River samples misclassified primarily to Canada.

Mean classification accuracy of a 7-way river of origin model was 43.5%, or 3.0 times greater than random chance (Table 5). The Salcha River showed the greatest classification accuracy (68.8%), while the Anvik River showed the least (19.6%). Andreafsky, Anvik and Nulato Rivers classified primarily among themselves as a group (94.8%, 89.2% and 93.3%, respectively) supporting pooling of these rivers into a lower river standard. Samples from the Jim River misclassified primarily to Canada. Chena and Salcha Rivers classify primarily to each other as a group (67.8% and 84.4%, respectively) supporting pooling of these rivers into a middle river standard. Misclassification of age 1.3 Canadian tagging fishwheel samples to Alaskan rivers was 55.8%. However, of 487 Alaskan escapement samples collected and classified in this age 1.3 model, 9.2% misclassified to Canada.

Catch Allocation

Catches are in the process of being allocated using run and river of origin classification models of ages 1.4 and 1.3 fish. Results will be available in a future report.

Table 5. Classification accuracy of a linear discriminant river of origin model for age 1.3 Yukon River chinook salmon, 1986.

7-way including each Alaskan escapement sampled and Canadian tagging sample (Andreafsky, Anvik, Nulato, Jim, Chena, Salcha, Canada tagging)

River of Origin	Sample Size	Classified River of Origin						
		Andreafsky	Anvik	Nulato	Jim	Chena	Salcha	Can. Tag
Andreafsky	117	0.427	0.256	0.265	0.026	0.017	0.000	0.009
Anvik	46	0.326	0.196	0.370	0.087	0.000	0.000	0.022
Nulato	74	0.311	0.176	0.446	0.041	0.027	0.000	0.000
Jim	55	0.036	0.073	0.000	0.436	0.109	0.073	0.273
Chena	118	0.000	0.000	0.042	0.102	0.407	0.271	0.178
Salcha	77	0.013	0.000	0.026	0.026	0.156	0.688	0.091
Can. Tag	199	0.005	0.010	0.000	0.261	0.141	0.141	0.442

Mean Classification Accuracy: 0.435

Variables in the Analysis: 67,62,1,65,80,106

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Appendix Table 1. Scale variables screened for linear discriminant function analysis of ages 1.3 and 1.4 Yukon River chinook salmon.

Variable	1st Freshwater Annular Zone
1	Number of circuli (NC1FW)[1]
2	Width of zone (S1FW)[2]
3 (16)	Distance, scale focus (C0) to circulus 2 (C2)
4	Distance, C0-C4
5 (18)	Distance, C0-C6
6	Distance, C0-C8
7 (20)	Distance, C2-C4
8	Distance, C2-C6
9 (22)	Distance, C2-C8
10	Distance, C4-C6
11 (24)	Distance, C4-C8
12	Distance, C(NC1FW -4) to end of zone
13 (26)	Distance, C(NC1FW -2) to end of zone
14	Distance, C2 to end of zone
15	Distance, C4 to end of zone
16-26	Relative widths, (variables 3-13)/S1FW
27	Average interval between circuli, S1FW/NC1FW
28	Number of circuli in first 3/4 of zone
29	Maximum distance between 2 consecutive circuli
30	Relative width, (variable 29)/S1FW

Variable	Freshwater Plus Growth
61	Number of circuli (NCPG)[3]
62	Width of zone (SPGZ)[4]

Variable	All Freshwater Zones
65	Total number of freshwater circuli (NC1FW+NCPG)
66	Total width of freshwater zone (S1FW+SPGZ)
67	Relative width, S1FW/(S1FW+SPGZ)

-(Continued)-

Appendix Table 1. Scale variables screened for linear discriminant function analysis of ages 1.3 and 1.4 Yukon River chinook salmon (continued).

Variable	1st Marine Annular Zone
70	Number of circuli (NC1OZ)[5]
71	Width of zone (S1OZ)[6]
72 (90)	Distance, end of freshwater growth (EFW) to C3
73	Distance, EFW-C6
74 (92)	Distance, EFW-C9
75	Distance, EFW-C12
76 (94)	Distance, EFW-C15
77	Distance, C3-C6
78 (96)	Distance, C3-C9
79	Distance, C3-C12
80 (98)	Distance, C3-C15
81	Distance, C6-C9
82 (100)	Distance, C6-C12
83	Distance, C6-C15
84 (102)	Distance, C9-C15
85	Distance, C(NC1OZ -6) to end of zone
86 (104)	Distance, C(NC1OZ -3) to end of zone
87	Distance, C3 to end of zone
88	Distance, C9 to end of zone
89	Distance, C15 to end of zone
90-104	Relative widths, (variables 72-86)/S1OZ
105	Average interval between circuli, S1OZ/NC1OZ
106	Number of circuli in first 1/2 of zone
107	Maximum distance between 2 consecutive circuli
108	Relative width, (variable 107)/S1OZ

Variable	All Marine Zones
109	Width of 2nd marine zone, (S2OZ)
110	Width of 2nd marine zone, (S3OZ)
111	Total width of marine zones (S1OZ+S2OZ+S3OZ)
112	Relative width, S1OZ/(S1OZ+S2OZ+S3OZ)
113	Relative width, S2OZ/(S1OZ+S2OZ+S3OZ)

[1] Number of circuli, 1st freshwater zone.
[2] Size (width) 1st freshwater zone.
[3] Number of circuli, plus growth zone.
[4] Size (width) plus growth zone.
[5] Number of circuli, 1st ocean zone.
[6] Size (width) 1st ocean zone.